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Hearing on China's Five Year Plan, Indigenous Innovation
and Technology Transfers, and Outsourcing
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Mr. Chairman and members of the Commission:

Thank you for the opportunity to testify today on China's "indigenous innovation" policies and possible challenges for America. This issue is of great concern to my organization, the EWC, that seeks to promote better relations and understanding between the US and Asia.

The Commission, since its first report in 2002, has addressed China's innovation policy years before this policy made it into the media headlines. The hearing records contain valuable data and insights for scholars, business people and policy makers. Nevertheless, our understanding of how serious a challenge China's innovation policies are for America is still "work in progress".

My own research examines how China's innovation policy affects innovative capabilities and innovation strategies of Chinese companies. In a study that has just been published, I explore how China uses standardization as a tool for indigenous innovation. Specifically, the study reviews China's recent policy initiatives on four hot button policy issues: i) China's definition of indigenous innovation products; ii) the treatment of foreign companies in government procurement; iii) new regulations for patents included in standards; and iv) China's approach to Information Security Standards and Certification, with a focus on the National Information Assurance Policy Framework Multi-Level Protection Scheme [MLPS][1].

Based on this research, I will argue that China's innovation policy is not a threat to US leadership in science and technology. As demonstrated in the first part of the statement, the US retains a strong lead in overall innovative capacity, and China still has a long way to go to close the innovation gap.

Instead, China's progress in innovation should be seen as a wake-up call for America. Rather than fearing China and blaming it for our problems, we need to focus research and policy debates constructively on how this relationship can be improved. As discussed in parts 2 and 3 of the statement, both the US government and the private sector need to join forces to develop and implement:

- a <u>proactive and smart trade diplomacy</u> that understands the diverse forces and their conflicting agendas that drive China's innovation policy; and
- a <u>national strategy to upgrade America's innovation system</u> in order to cope with the challenge of China's innovation policy from a position of strength.

Both trade diplomacy and national innovation strategy are interrelated, and hence we need to pursue them simultaneously. Corrective action needs to start now, but there is still time to adjust policies and corporate strategies to the new challenges of an increasingly multi-polar global knowledge economy.

1. Evidence on China's progress in innovation and its persistent innovation gap

China's innovation policy has produced massive investments in R&D infrastructure and Higher Education "…on a scale and speed never seen before."[2] Since 2000, China has increased R&D spending roughly 10% each year—a pace the country maintained during the 2008-2009 recession. This sustained commitment to a rapid expansion of R&D sets China apart from the crisis-induced cuts in the US. As a result, China's share in global R&D spending has increased from 9.1% in 2008 to 12.3% in 2010, while the US share has declined from 35.4% to 34.4%. China's share is projected to grow further to 12.9% in 2011, overtaking Japan as the second largest R&D investor. (see **slide 1**[3])

Since 1998, the number of colleges has doubled, and the number of students has more than quintupled, from 1 million in 1997 to ca 6 million in 2007. This contrasts with the situation in the US where state universities are suffering the impact of budget cuts. What matters is that China's domestic science and engineering doctorate awards have increased more than tenfold since the early 1990s, to about 21,000 in 2006, nearing the number of S&E doctorates awarded in the United States (**slide 2**).

Furthermore, China is now one of the four leading countries in science and technology publications, with particular strengths in materials science (especially nano-technology[4]), analytical chemistry, rice genomics, and stem cell biology. China's share in scientific publications and co-authored articles has exploded, catapulting China as the second largest source country behind the US (**slides 3,4**).

Of particular interest is China's patent boom**.** In terms of total patenting activity, China has overtaken Korea and Europe, and is catching-up with the US and Japan[5]. (**Slide 5**) Domestic patent applications by Chinese nationals have overtaken foreign applications since 2003. (**slide 6**) In 2009, Chinese nationals accounted for nearly 90 percent of patent applications in China. This indicates that China's innovation policy has been successful, at least in quantitative terms.

Nearly three quarters of resident applications in China are for *utility model* and *industrial design* patents. (**slide 7**) Some observers consider *utility model* patents as "junk"[6]. However, innovation economists have emphasized that *utility model* patents have played an important role in fostering earlier catching-up processes in Germany, Japan, Korea and Taiwan[7]. What matters is that China's utility model patents facilitate low-budget forms of innovations[8]. An example of this type of successful low-cost innovations are no-name *shanzhai* (unlicensed) handsets that are estimated to have at least a 40 percent share of the Chinese handset market. The situation however is changing fast - the recent Revision of China's Patent Law in October 2009 seeks to discourage utility patents and shifts the emphasis on invention patents.

In fact, a handful of leading Chinese firms and research institutes have moved beyond incremental innovations and are developing portfolios of higher-quality patents (**slides 8 and 9**)[9]. The test flight of China's next-generation stealth fighter J-20 during Defense Secretary Gates' January 2011 China visit highlights the accelerating development of China's defense science, technology, and innovation capabilities.

Another prominent example of innovation progress is that China now has the world's fastest supercomputer at the National Supercomputing Center in Tianjin. (**slide 10**).That machine not only has greater computing capacity than the second ranked US Department of Energy Oak Ridge National Laboratory, but it also consumes considerably less energy.

What is interesting is that the Tianjin super computer is an *architectural innovation* that relies on US technology[10]. The Tianjin machine uses energy-saving graphic processors supplied by Nvidia, a chip design company based in Santa Clara/Ca., but the Chinese engineers have changed the way these processors work together.

And yet the gap in innovation capacity persists, and China's leadership is very conscious that the US retains a strong lead in R&D and per capita number of scientists and engineers (**slide 11**), and in patent applications (**slides 12-14**). A telling example is that no Chinese company is among the top 20 global R&D spenders in the IT industry (**slide 15**)[11]. According to WIPO, China owns just two percent of worldwide patents, with 95% of China's patents being in force in China only. And all 15 leading companies with the best record on patent citations are based in the United States (9 in the IT industry).

Root causes for China's persistent innovation gap range from severe quality problems in education to plagiarism in science, and barriers to entrepreneurship and private R&D investment. An important weakness of China's innovation policy are elaborate lists of products and technologies that are constructed to assess compliance with China's standardization and certification requirements. These lists risk being quickly outdated and bypassed. Even more important for China's objective to foster indigenous innovation is that such control lists focus on *existing technologies,* rather than on the future innovations that they are designed to promote.

In addition, China's progress in innovation is likely to be stifled by China's policy on Information Security Standards and Certification. In its current form, this policy would create unintended disruptive side effects for the upgrading of China's innovation capacity and could create potentially serious trade conflicts (Ernst, 2011, chapter II).

2. A proactive and smart trade diplomacy

China's innovation policy no doubt has increased technology-related trade conflicts between the US and China, adding further to contentious disputes about exchange rates and foreign direct investment. The US government considers China's innovation policy to be "discriminatory", because it "unfairly favor[s] domestic producers at the expense of foreign firms, … [and]… because of …[its]… threat to global intellectual property protections, fair government procurement policies, market competition and the freedom of U.S. companies to decide how and when to transfer technology."[12] And the US Chamber of Commerce argues that China's innovation policy " …restricts the ability of American companies to access the market and compete in China and around the world by creating advantages for China's state-owned enterprises and state-influenced champions, … [and has]… the potential to undermine significantly the innovative capacity of the American economy in key sectors, and, consequently, harm the competitiveness and livelihood of American business and the workers that they employ."[13]

America has the right to insist on safeguards against forced technology transfer through policies like compulsory licensing, information security standards and certification, and restrictive government procurement policies. For the US government, this implies that there is no escape from the day-to-day grind of trade negotiations. But an activist and smart trade diplomacy requires substantial investments and a much improved capacity of government agencies for monitoring, intelligence gathering and research.

For US business, this implies that it needs to contribute to the necessary funds, given the severe restrictions on public budgets. In addition, US private industry needs to be more forthcoming in providing the US government with information and evidence especially on employment effects (both at home and overseas) of its manufacturing and R&D activities in China, as well as on cyber security violations, IP theft, and other proven costs and damages of Chinese policies.

To be effective, America's trade negotiations with China need to be based on three pillars:

- Understand diverse stakeholders and their conflicting agendas
- Examine what might induce policy adjustments
- Establish shared benefits and reciprocity.

i) Understand diverse stakeholders and their conflicting agendas

It is essential that both the US government and private industry support research on the diverse stakeholders and their conflicting agendas that drive China's innovation policy.

From outside, China's innovation policy often seems to present a homogenous picture of a top-down "model of neo-mercantilist state developmental capitalism."[14] The official message is that China's leadership is convinced that indigenous innovation is the key to removing poverty and for catching up with the US, EU and Japan. Indigenous innovation is considered essential not only for moving beyond the precarious export-oriented growth model. At stake really is the survival of the system. According to government projections, China's economy must grow by more than seven to eight per cent a year if social unrest is to be kept under control[15]. Chinese leaders understand that export-led growth can no longer guarantee such rapid growth. Hence they place all their bets on indigenous innovation as a catalyst for industrial upgrading.

Such a high-level strategic commitment cannot be easily changed through external pressure, especially for policies that China's leaders think are successful. While "…blaming China for our economic problems …is tempting", this may "ultimately…[be]…an empty gesture."[16] A proactive and smart US trade diplomacy needs to take a closer look at the surprisingly fragmented Chinese innovation system that involves diverse stakeholders with conflicting interests. Identifying those diverse stakeholders might help to improve the leverage of US trade diplomacy.

Three main groups of stakeholders can be distinguished. First, China's exporting industry is a strong supporter of compliance with WTO commitments. This position reflects China's deep integration into global corporate networks of production and innovation[17]. Support for greater compliance with international standards also comes from leading Chinese ICT firms which have accumulated a critical mass of intellectual property rights, like Huawei, ZTE, Lenovo and Haier.

Second, strong support for developing China's indigenous innovation capabilities can be found in research labs, parts of the domestic hi-tech industry with limited export exposure, as well as in the military, the CCP, and large parts of the general public. This coalition of domestic stakeholders is supporting, for instance, policies on patent licensing for standards that seek to reduce licensing fees to foreign patent holders , as embodied initially in the *Draft Rules on Patents included in Standards*, issued by the Standard Administration of China (SAC) in November 2009.

Third, China's security and military establishment plus top leadership echelons view information security and certification regulations as an integral part of China's innovation strategy. Recent policy initiatives (especially China's National Information Assurance Policy Framework Multi-Level Protection scheme [MLPS], issued by the Ministry of Public Security in June 2007; and CNCA's Information Security Testing and Certification Regulations) are driven by fears that China's critical information networks provide an easy "target of attack, sabotage, and terrorism by hostile forces and elements."[18]. A strategic assumption is that control over standards and a strong Chinese information security industry are necessary to protect China's information security.

It is difficult for outsiders to assess which of these three stakeholder coalitions has most leverage in shaping decisions on China's innovation policies. A detailed analysis of recent developments of China's innovation policies finds a fairly consistent pattern of China's response to foreign complaints[19]. In round one, PRC government regulations start out with quite demanding requirements that exceed established international norms. This typically gives rise to a wave of criticism from foreign enterprises and business organizations, but also from Chinese companies that have established a significant position in the international market and that have begun to accumulate a reasonably broad portfolio of intellectual property rights. In response to this criticism, round two then leads to some adjustments in PRC government regulations that combine a selective relaxation of contested requirements with persistent ambiguity.

This raises the question: What is going to happen in further rounds of negotiation? In the run-up to the 18th party congress, there are signs that Chinese policy-makers are moving towards a more dogmatic position on economic policies, political ideology, internal control policies, and geo-strategic and foreign policy positions. It is unclear at this stage whether this shift towards greater dogmatism is a temporary tactical move dictated by the power struggles in the run-up to the party congress. Some observers see a growing role of security considerations in China's innovation policy[20]. Or can we expect, once the congress is over, a strategic shift, albeit very gradually, to greater openness and transparency, as China needs foreign technology and as it needs to adjust to the requirements of its deep integration into the global economy?

ii) What might induce policy adjustments?

To identify areas where adjustments in policy implementation might be possible, the US needs to put in place a process of continuous monitoring and in-depth research on how Chinese innovation policies are evolving over time. An important insight that could structure this research is that "China is approaching the issue of technological leadership from a position of weakness, not strength."[21] I agree. China's main weakness is the persistent innovation gap with the US, the EU and Japan described in part one of this statement. Combined with China's deep integration into international trade and global networks of production and innovation, this provides a powerful rationale for at least tactical compromises with foreign complaints.

This highlights a fundamental dilemma for China that could provide leverage for US trade diplomacy: How can China reconcile the primary objective of strengthening indigenous innovation with the country's leading role in international trade and its deep integration into global corporate networks of production and innovation? And specifically, what compromises are necessary in China's policies and regulations to avoid unintended disruptive effects on China's still critically important export drive?

Overall, I share Scott Kennedy's assessment that, when push comes to shove on how to implement China's indigenous innovation policy, "… the most mercantilist elements are regularly rebuffed, and given the array of interests in favor of a more open innovation strategy, that pattern is unlikely to change….[As]… Chinese companies and officials are engaging – if not fully embracing – global regimes for intellectual property, standards, and even government procurement…, a socialization process is gradually encouraging more constructive behavior so that competition and cooperation occur within the context of a clearer set of boundaries." [22]

iii) Shared benefits and reciprocity

As for the third pillar, US trade negotiations with China have significantly greater chances of success if there is a sharing of benefits that is acceptable to both sides. It is important to emphasize that China's innovation push also provides ample opportunities for cooperation. In fact, both China and the US have a strong interest in deepening cooperation.

It certainly is in America's interest to build coalitions with Chinese stakeholders to foster U.S.-China cooperation on science, technology, and innovation. China's persistent innovation gap implies that China's innovation push creates new markets for American firms as Chinese firms continue to need access to American technology. But implementing such cooperation faces many hurdles. These partnerships need to be on an equal footing, with *reciprocity* of rights and obligations on contentious issues like, for instance, finding the right balance between the protection of intellectual property rights and China's interest in technology diffusion.

Establishing such reciprocity between countries at different stages of development will not be easy. While incumbent industry leaders seek to retain the *status quo*, newcomers like China seek to adjust the old rules to reflect their interests as latecomers. But progress towards adjusted rules of reciprocity should be possible, once the US and China accept that, while their economic systems are different, their economies and innovation systems are interdependent.

China, for instance, ought to acknowledge that America needs safeguards against forced technology transfer through policies like compulsory licensing, information security standards and certification, and restrictive government procurement policies. The US, in turn, needs to acknowledge that Chinese firms feel disadvantaged by restrictions on Chinese foreign direct investment, and by restrictions on the export of so-called 'dual-purpose" technologies to China. The US also needs to engage more actively with Chinese concerns for instance about the distribution of benefits of the current rules of patent licensing and of the role of essential patents in critical interoperability standards.

To move towards greater reciprocity, it is necessary to increase the level of trust. While this is not easy, given deeply entrenched fears in both countries, *creative incrementalism* through *learning-by-doi*ng can help to move things forward. As suggested by Michael Borrus in a recent symposium of the National Research Council on Building the 21st Century: U.S.-China Cooperation on Science, Technology, and Innovation: "We need to try some things together, demonstrate mutual gain, and then turn those smaller-scale collaborations into larger collaborations."[23]

3. An integrated national innovation strategy

The US is still way ahead in overall innovation capacity, and fears of China's threat are exaggerated. Trade diplomacy is important, but on its own it is insufficient. China's progress in innovation should be seen as a wake-up call for America. Both the US government and the private sector need to join forces and develop a national strategy to enhance the country's innovative capacity and to create well-paying jobs in research, product development, and engineering, as well as in manufacturing.

Apple's iPod production model provides at best a short-term palliative – once manufacturing moves offshore, higher value jobs in engineering, product development and research are following[24]. To develop viable policies, we need systematic empirical research that provides robust data both on the employment effect of offshore outsourcing by US companies and on job losses in the US that can be attributed directly to discriminatory policies by the Chinese government.

Such research unfortunately is still in an embryonic state.Thanks to the Upjohn Institute for Employment Research and the International Trade Commission (ITC), we now have first rough estimates[25]. Unfortunately, unresolved problems with research methodology constrain the usefulness of these estimates. There is a glaring lack of statistics about how many R&D jobs have been offshored from the United States to China and in what industries. One reason is limited access to corporate employment data. According to a study prepared for the National Bureau of Economic Research, "the U.S. government does not measure the number of jobs offshored."[26] And the latest report of the Congressional Research Service concludes that "…[t]he short- and long-run labor market implications of offshore outsourcing are … unclear."[27]

This makes it difficult to separate out the specific employment impact of China's innovation policy. For instance, in its analysis of the telecommunications industry, the ITC study acknowledges that "it is impossible to attribute U.S. telecommunications trade and employment directly to Chinese indigenous innovation policies." (International Trade Commission, 2011, p.5-27). In addition, it is difficult to analyze the economic impact of China's innovation policy on US employment as China's policies are in flux, remain ambiguous, and are evolving rapidly and often in unpredictable ways[28].

Equally important, we need research that facilitates decisions on what government and private business need to do to further enhance America's formidable innovative capacity. US policy debates should focus again on a fundamental question: How can we build on existing strengths to upgrade America's innovation system? In line with the tradition of the American Revolution, America's innovation system is shaped by a unique mix of voluntarism, local control, meritocracy, and individualism and a preference for the private coordination of economic activity. This system has produced a treasure trove of innovations.

There is little doubt that places like Silicon Valley and Route 128, US hotbeds of innovation, remain among the best places to be for high-risk, knowledge intensive innovation activities. This is because such locations typically include a broad portfolio of support services - including legal, finance, and property development - that facilitate rapid adjustments of business models to changing requirements of markets and technology. These are also privileged places to collect strategic market intelligence from the most demanding lead users. Additional strengths of the US innovation system include (1) the presence of the world's leading research universities, (2) an unrivaled exposure to leading-edge management practices for R&D projects, and (3) a high mobility of knowledge workers that facilitates quick and relatively hassle-free knowledge diffusion.

However, barriers to and disincentives for innovation in the US remain aplenty, and we need to find ways to overcome them. For instance, a major challenge to the US innovation system is that federally-funded R&D is under tremendous pressure, while a severe fiscal crisis forces states and local governments to reduce drastically their R&D funding. This matters as US companies are increasingly relying on the federal government and on universities and federal laboratories for basic research[29].

In addition, as US companies need to please their investors and their ever increasing return-on-investment requirements, they are prone to offshore not only manufacturing but also engineering, new product development and research. Following this financial logic, American companies tend to sign agreements in China that are harmful over the long term in order to generate sales during the current or next quarter.

To address these problems, the United States needs a "new national innovation strategy" that combines a reliance on decentralized market forces with reinvigorated public-private partnerships[30]. We also need a debate on how to improve the role of the government as a provider of infrastructure, as an enabler of basic research and as a coordinator and, if necessary, an enforcer of the rules of the game through antitrust policy and smart trade diplomacy.

Many reports have identified key priority areas that need change[31]. This includes overdue improvements in the US education system, so that students are encouraged to study science and technology and to acquire complementary management, interpretative, cross-cultural and other "soft" capabilities[32]. Equally important is a realignment of fiscal incentives to spur early-stage investments in new technologies like low-carbon energy, and reforms in the financial system to improve allocation of capital and create space for patient innovation funds.

According William Brody - then president of Johns Hopkins University and co-chairman of the U.S. Council on Competitiveness's National Innovation Initiative - the United States is facing a serious challenge: "We are losing our collective will to fund basic research… (which) has failed to demonstrate a return on investment that satisfies the ravenous appetite of financial markets for short-term earnings growth."[33] After the global financial crisis of 2008, there is an even greater need for policies that facilitate the supply of patient innovation investment funding.

In the end, America needs to rethink some basic assumptions of its innovation strategy when global corporate networks integrate national production and innovation systems across sector and geographic boundaries and when new players like China enter global competition. In this new multi-polar global economy, what is the appropriate role for national public policies, as globalization becomes ubiquitous, and what are inherent limitations of such policies? How should one define the interests of a country? Are interests of the country and of its corporations aligned, or are there fundamental conflicts?[34]

If employment generation is the primary objective, this implies that manufacturing in America matters. Without a solid manufacturing base, "we will never be able to create the jobs needed to bring us out of this recession, and we will destroy the lives of millions of our citizens and decline as a nation."[35]

I'd like to conclude my statement with a quote from the Commission's 2005 Annual report that could serve as a motto for America's new innovation strategy: "Our public officials must develop policies that give U.S. companies incentives to serve America's national interest by keeping and creating in this country good paying, high tech jobs that sustain high living standards and contribute to the maintenance of our defense industrial and tax bases. This must be a top priority."[36]

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[1] Ernst, D., 2001, *Indigenous Innovation and Globalization – the Challenge for China's Standardization Strategy*, co-published by the University of California Institute on Global Conflict and Cooperation (IGCC), and the East-West Center, June, 122 pages.

[2] Battelle, 2010, *2011 Global R&D Funding Forecast*, p.28, http://www.battelle.org/aboutus/rd/2011.pdf

[3] Please refer to the slides in the Appendix.

[4] China ranks third (after US and Japan) in the number of nanotech publications, and the Chinese Academy of Science is ranked fourth for nano-science citations (after UC Berkeley, MIT and IBM).

[5] WIPO, 2010, *World Intellectual Property Indicators*, World Intellectual Property Organization, Geneva

[6] McGregor, J., 2010, *China's Drive for 'Indigenous Innovation'. A Web of Industrial Policies*, report commissioned by the US Chamber of Commerce, page 27, https://www.uschamber.com/reports/chinas-drive-indigenous-innovation-web-industrial-policies.

[7] Odagiri, H., A.Goto, A. Sunami, and R.R. Nelson, eds., *Intellectual Property Rights, Development and Catch-Up*, Oxford University Press, Oxford etc.

[8] China's *utility model patents* protect any new technical solution relating to the shape and/or structure of a product, which is fit for practical use. Utility patents offer the same protection (albeit for a shorter time span) as invention patents. But they are quicker and cheaper to obtain since a utility model receives only preliminary examination rather than the full substantive examination of an invention application.

[9] Little is known about what is happening in second-tier Chinese firms and research institutes.A joint research project by the East-West Center and the Institute for Global Conflict and Cooperation (IGGC) at UC San Diego seeks to shed light on this hidden part of China's innovation system.

[10] For a taxonomy of different types of innovation, see Ernst, D., 2009, A New Geography of Knowledge in the Electronics Industry? Asia's Role in Global Innovation Networks. Policy Studies No. 54, August, East-West Center, Honolulu, HI, chapter II.

[11] The 700 largest R&D spenders (mostly large U.S. firms) account for 50% of the world's total R&D expenditures and more than 2/3 of the world's business R&D.

[12]Demetrios Marantis, Deputy US Trade Representative, quoted in "UPDATE 2-China trade behavior imperils ties – USTR", at http://www.reuters.com/assets/print?aid=USN1520929420100715.

[13] Testimony by Jeremi Waterman, Senior Director, Greater China at the US Chamber of Commerce before the US International Trade Commission Hearing on *China: Intellectual Property Infringement, Indigenous Innovation Policies, and Frameworks for Measuring the Effects on the US Economy.* (Investigations No. 332-514 and 332-519)*"*, June 15, 2010.

[14] Wolff, Alan Wm., 2011, China's Indigenous Innovation Policy, Testimony before the U.S. China Economic and Security Review Commission Hearing on China's Intellectual Property Rights and Indigenous Innovation Policy, Washington, D.C., May 4: page 3

[15] Quoted in Anderlini, J., 2011, "Beijing must avoid at all cost a giant pop in house prices", *Financial Times*, June 6: p. 4.

[16] Additional views of Commissioners Robin Cleveland and William A. Reinsch, in: *2010 Report to Congress of the U.S.-China Economic and Security review Commission*, Washington, D.C., November 2010: p.278

[17] A good proxy indicator for China's integration into global production networks is that foreign-invested enterprises dominate China's manufactured exports - they account for 58% of China's total exports, and 88% of its high-technology exports. As for integration into global innovation networks, China is the third most important offshore R&D location for the 300 top R&D spending multinationals, after the United States and the United Kingdom. Today, China is the largest 'net importer' of R&D, and FIEs account for USD 24.7 billion in R&D spending, about one fourth of China's 2007 R&D spending.

[18] LOU Qingjian. Vice Minister, Ministry of Information Industry, at BOAO Forum 2006, at http://www.boaoforum.org/AC2006/yjgE.asp, accessed July 6, 2010

[19] This is true for China's definition of products that contribute to indigenous innovation; the revision of government procurement regulations; and new regulations for patents included in standards.

[20] According to Tai Ming Cheung, "the influence of national security considerations in shaping Chinese innovation and technology development policies is likely to become even more central with China's global rise and the growing demands of its defense establishment." (Cheung, Tai Ming, 2011, The Evolving Relationship Between Technology, Innovation and National Security in China, paper prepared for the conference on the *Political Economy of China's Technology and Innovation Policies*, UC San Diego, June 27-28: p.19).

[21] Levy, Philip I., 2011, *China's Indigenous Innovation Policy and U.S. Interests*, Written testimony before the House Committee on Foreign Affairs Subcommittee on Terrorism, Nonproliferation, and Trade, 9 March: page 8.

[22] Kennedy, S. 2010. "Indigenous Innovation: Not as Scary as It Sounds." *China Economic Quarterly*, September: pages 19 and 20.

[23] Symposium on Building the 21st Century: U.S.-China Cooperation on Science, Technology, and Innovation, National Academy of Sciences, Washington, D.C., 18 May 2010

[24] Ernst, D., 2005, "Complexity and Internationalisation of Innovation: Why Is Chip Design Moving to Asia?", *International Journal of Innovation Management*, March: 47–73.

[25] Lazonick, W., 2009, *Sustainable Prosperity in the New Economy? Business Organization and High-tech Employment in the United* States, the Upjohn Institute for Employment Research, Kalamazoo, Michigan; Houseman, Susan, Christopher Kurz, Paul Lengermann and Benjamin Mandel. 2011. "Offshoring Bias in U.S. Manufacturing." Journal of Economic Perspectives 25(2): 111-132: and International Trade Commission, 2011, *China: Effects of Intellectual Property Infringement and Indigenous* Innovation Policies on the US Economy, USITC Publication 4226, May, chapter 5.

[26] Freeman, R.B., 2005, "Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership." *NBER Working Paper 11457*. Cambridge, MA: National Bureau of Economic Research: p. 25

[27] Levine, L., 2011, *Offshoring (or Offshore Outsourcing)and Job Loss Among U.S. Workers*, Congressional Research Services, Washington, D.C.January 21, page 1

[28] "Many policies remain in draft form, many of the implementing regulations for major laws are still not in place, and enforcement of most indigenous innovation policies has not yet begun. Much of the concern thus reflects fear of future Chinese policies and of the way new laws may be implemented, and not simply objections to policy actions that the Chinese government has already taken. It remains unclear how the effects of the new policies will play out." International Trade Commission, 2010, China: Intellectual Property Infringement, Indigenous Innovation Policies, and Framework for Measuring the Effects on the US Economy, USITC Publication 4199, November: chapter 5: p. 5-2.

[29] Block, F. and M.R. Keller, 2011, "Where do Innovations Come From? Transformations in the U.S.Economy, 1970-2006", chapter 8 in Block, F. and M.R. Keller, eds., *State of Innovation. The U.S. Government's Role in Technology Development*, Paradigm Publishers, Boulder, London

[30] Successful examples are the DoD's Defense Advanced Research Projects Agency (DARPA) and the Small Business Innovation Research (SBIR) Program administered by the U.S. Small Business Administration.

[31] See, for instance, National Academy of Sciences. 2005, *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Future*. Washington: National Academies Press; and National Science Board, 2010, *Science and Engineering Indicators 2010, Vol. I*. Arlington, VA: National Science Foundation.

[32] Lester, R.K. and M. J. Piore, 2004, *Innovation – the Missing Dimension*, Harvard University Press, Cambridge/Mass etc

[33] As quoted in the *Financial Times*, August 19, 2005.

[34] See, for instance, the testimony of Ralph E. Gomory (a former IBM Senior Vice President of Science and Technology and President Emeritus, Alfred P. Sloan Foundation) to the *U.S.-China Economic and Security Review Commission*, March 24, 2009, who argues that the growing divide in the US labor market indicates that "the interests of many of our global corporations and the interests of the nation have diverged."

[35] Comments by Daniel M. Slane at the February 15 Congressional Briefing on Manufacturing, Job Creation, and Trade with China, at http://supportustradelaws.com/wp-content/uploads/2011/03/Dan-Slane-Feb-15-cong-briefing-remarks.pdf

[36] Additional Views of Commissioner Patrick A. Mulloy, in *2005 Report to Congress of the US-China Economic and Security Commission*, Washington, D.C., November 2005: p.216

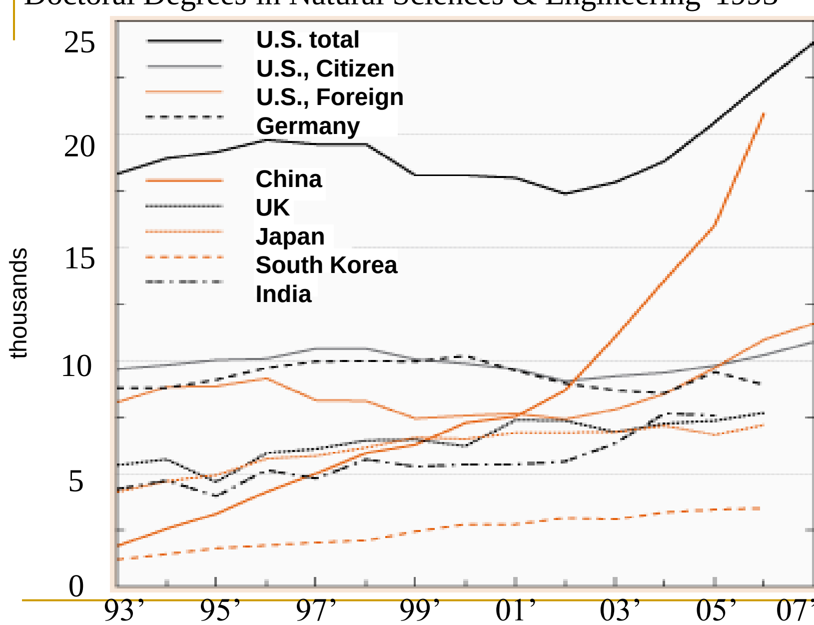
Share of total global R&D spending [%]

	2008	2009	2010	2011
US	35.4	34.7	34.4	34.0
Europe	24.9	24.1	23.3	23.2
Japan	13.2	12.6	12.3	12.1
Asia*	18.8	21.0	22.5	23.2
China	**9.1**	**11.2**	**12.3**	**12.9**
India	2.4	2.5	2.9	3.0

* Without Japan Battelle 2011 Global R&D report © Dieter Ernst

1

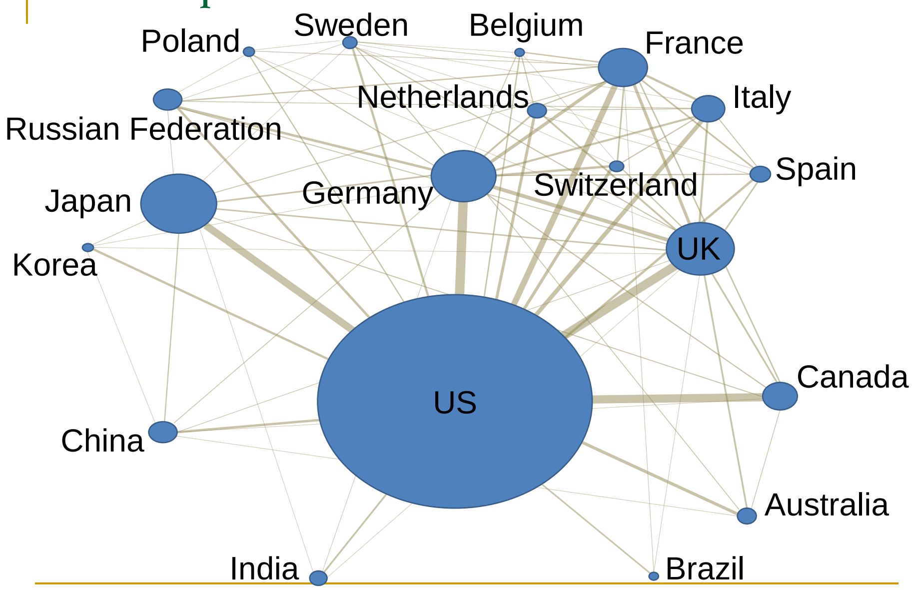
Doctoral Degrees in Natural Sciences & Engineering 1993 -- 2007



National Science Board, Science and Engineering Indicators 2010 © Dieter Ernst

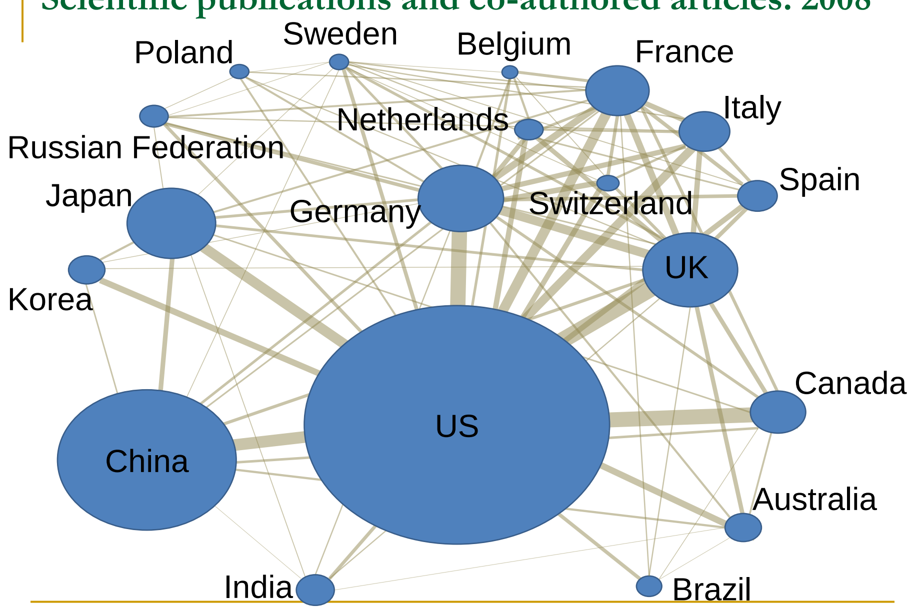
2

Scientific publications and co-authored articles: 1998



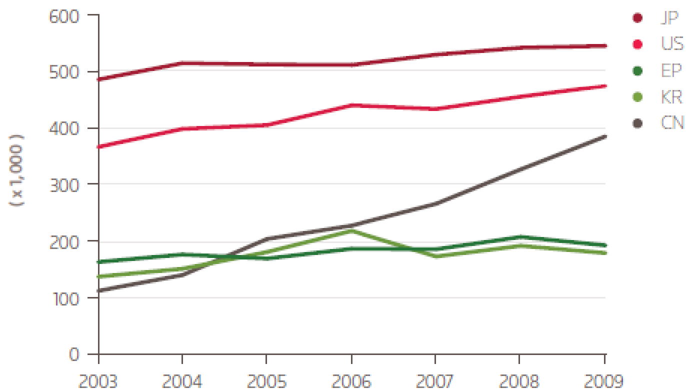
OECD Science, Technology and Industry Outlook 2010

Scientific publications and co-authored articles: 2008



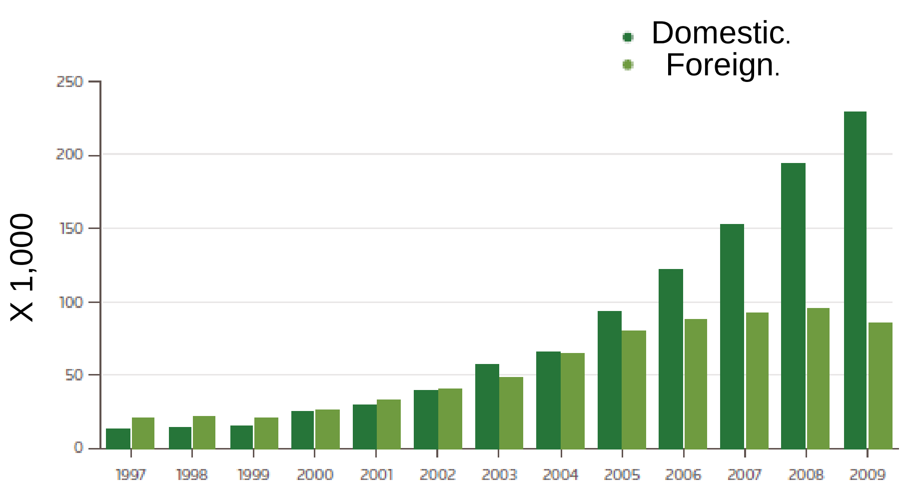
Source: OECD Science, Technology and Industry Outlook 2010

Total Patent Volume



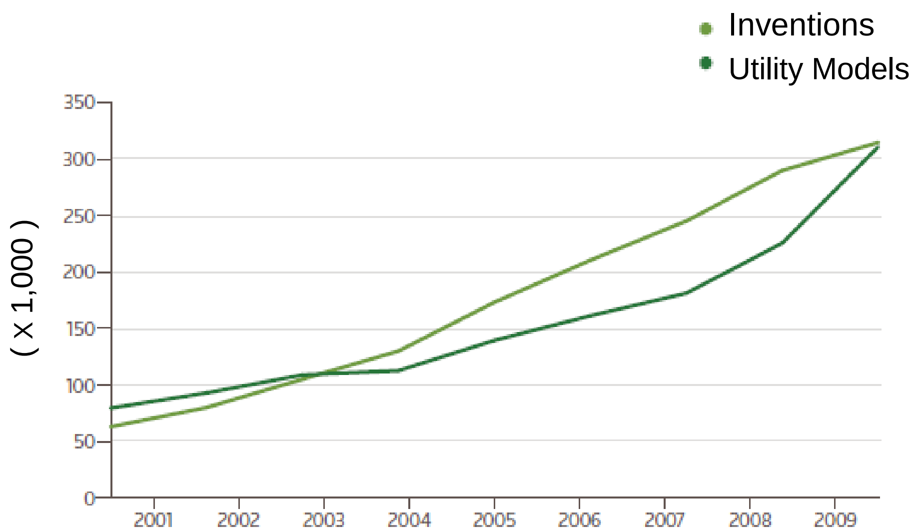
Thomson Reuters 2010

Domestic vs. Foreign Chinese Patent Filings (Applications)



Thomson Reuters 2010

Utility Model vs. Invention Patent Filings in China



Thomson Reuters 2010

Is China moving beyond incremental innovations?

Architecture	Components: unchanged	Components: changed
changed	**Architectural** cost-saving disruptive platforms (Huawei); supercomputer; COMPASS (SNS)	**Radical** new drugs; nano; stem cell biology; LAM; J-20 fighter; space & missiles
unchanged	**Incremental** add a new feature to an existing product; cost-saving process & services	**Modular** BYD eCar battery; mobile chipsets; small organic molecules

LAM= Laser Additive Manufacturing

Huawei – a smart mix of innovations

- Broad portfolio of **essential patents** in important technologies (IPv6 and beyond; next-generation mobile communications; convergence of fixed and mobile networks)
- Focus on **"customer-centric innovation"** → cost-saving service delivery platforms requested by the telecom operators define Huawei's choice of technology and standards

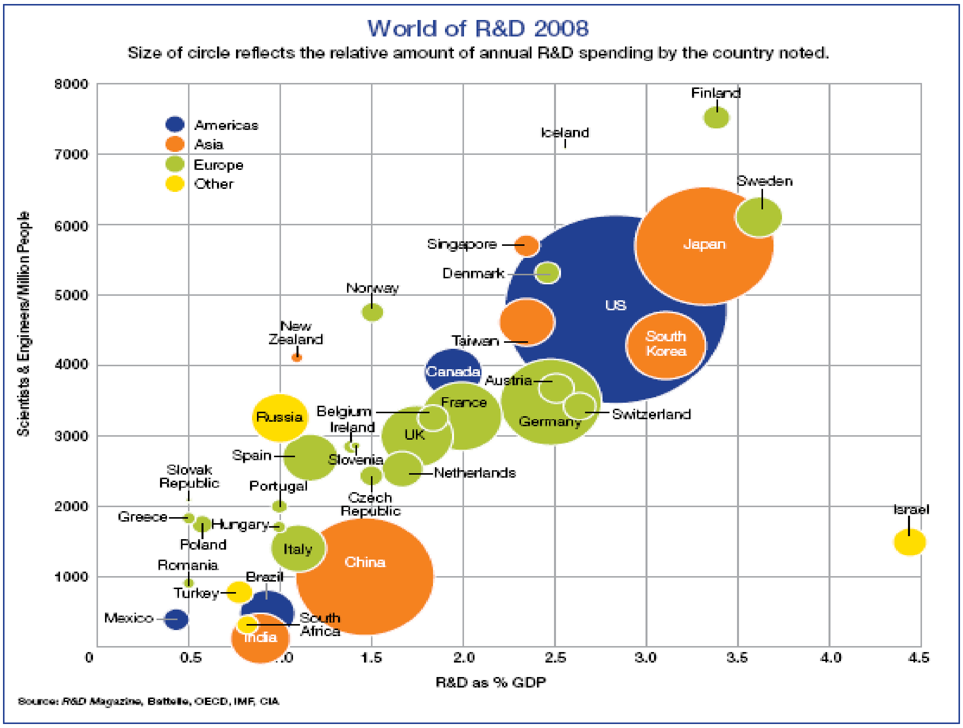
➢ ***But where are other Huaweis, ZTEs, Hai'ers?***

9

World's Top Five Supercomputers

Rank	Site	Computer/ Year Vendor	Cores	R_{max}	R_{peak}	Power (kW)
1	National Supercomputing Center, Tianjin China	Tianhe-1A - NUDT TH MPP, X5670 2.93Ghz 6C, **NVIDIA GPU**, FT-1000 8C / 2010 NUDT	**186368**	**2566.00**	**4701.00**	**4040.00**
2	DOE/SC/Oak Ridge National Laboratory USA	Jaguar - Cray XT5-HE Opteron 6-core 2.6 GHz / 2009 Cray Inc.	**224162**	**1759.00**	**2331.00**	**6950.60**
3	NSCS(National Supercomputing Centre),Shenzhen China	Nebulae - Dawning TC3600 Blade, Intel X5650, **Nvidia** Tesla C2050 GPU/ 2010 Dawning	**120640**	**1271.00**	**2984.30**	**2580.00**
4	GSIC Center, Tokyo Institute of Technology Japan	TSUBAME 2.0 - HP ProLiant SL390s G7 Xeon 6C X5670, Nvidia GPU, Linux/Windows / 2010 NEC/HP	**73278**	**1192.00**	**2287.63**	**1398.61**
5	DOE/SC/LBNL/NERSC USA	Hopper - Cray XE6 12-core 2.1 GHz / 2010 Cray Inc.	**153408**	**1054.00**	**1288.63**	**2910.00**

Top 500, 2010



China's gap in PCT applications

- In 2010, China published PCT filings* grew by 56 %, from 7,900 in 2009 to 12,337 in 2010
- ZTE is # 2 [+20%], Huawei is #4 [total of 42,623 PCT applications]
  - **No other Chinese company is among the top 100 applicants**
  - **No Chinese university is among the top 600 applicants**
- China still lags way behind the US in terms of the overall volume of PCT applications.
  - In 2008, the US filed 51,673 PCT applications
  - China filed 6,126 PCT applications

* *The Patent Cooperation Treaty (PCT) provides a unified procedure for filing patent applications to protect inventions in each of its contracting states.*

WIPO data base 2011

China's Patent Applications*: 2003-2007

* Total of domestic & international applications

Electrical engineering:	China	US	Germany	NL
Electrical machinery, apparatus, energy	**26,803**	68,760	42,086	6,167
Audio-visual technology	**16,739**	42,735	15,176	14,216
Telecommunications	**32,098**	76,564	15,389	5,755
Digital communication	**31,679**	72,334	13,650	4,549
Computer technology	**28,691**	191,835	28,184	10,370

Heavy focus on ICT: 50% of all patents in China are for ICT

WIPO database, 2011 © Dieter Ernst

China's Patent Applications: 2003-2007

Instruments:	China	US	Germany	NL
Optics	**12,270**	40,779	12,566	6,319
Measurement	**21,392**	66,252	34,065	5,462
Medical technology	**10,806**	138,389	25,002	5,304

Chemistry:	China	US	Germany	NL
Pharmaceuticals	**43,508**	102,133	22,203	4,135
Food chemistry	**17,006**	18,655	3,835	4,123
Basic materials chemistry	**20,313**	41,444	21,106	4,618
Materials, metallurgy	**20,142**	17,908	11,707	1,164

WIPO database, 2011 © Dieter Ernst

* Total of domestic & international applications

How serious a challenge are Chinese firms to MNCs' R&D leadership in the IT industry? [$ billion]

- No Chinese company among top 20 global R&D spenders
- Microsoft (9.010), Nokia (8.240), Samsung (6.002), IBM (5.820), Intel (5.653), Cisco (5.208),
- **Huawei (2.03), ZTE (0.845)**
- 2 Chinese companies are in the group of companies with the fastest R&D growth between 2000 & 2009: Huawei (+29%) & ZTE (+24%)

Booz&Co.,, 2010 & company reports, 2010